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How could Johnny Utah and Bodhi survive the skydiving jump in *Point Break*?

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Abstract
The 1991 American crime thriller *Point Break* is famous for its action-packed adrenaline-filled scenes. It gives the famous scene where a mid-air fight between the two main characters causes the parachute to be pulled only 8 seconds before hitting the ground. This paper investigates how large the cross-sectional area of the parachute would have had to have been to slow them down to safe speed of 6 ms^{-1} in 8 seconds before hitting the ground. It results that the cross-sectional area of parachute would have to have been 59.62 m^2 to ensure their safety.

Introduction
Point Break is an American action crime thriller starring Hollywood Stars Keanu Reeves and Patrick Swayze [1]. One famous scene, Bodhi (Swayze) jumps out of a plane and Johnny Utah (Reeves) follows without a parachute. They end up on top of each other in a mid-air fight, causing Bodhi to pull the parachute only 8 seconds before they hit the ground, and they miraculously survive. This paper aims to determine the feasibility of this adrenaline-filled scene, by calculating how large the cross-sectional area of the parachute would need to be to ensure their survival.

Figure 1 – Johnny Utah and Bodhi in the famous scene. Utah (back) has no parachute and Bodhi (front) has a parachute [1].

Discussion
To know how fast Utah and Bodhi were travelling, the terminal velocity must be considered. Terminal velocity is the highest attainable velocity by an object falling through a medium [2]. By using the terminal velocity, it is assumed that the men were falling together for enough time to be able to reach it. This is calculated by equation 1 [2]. The mass, m, of the men is assumed at 150 kg, with each of the men weighing a healthy 75 kg each [3]. They are falling through air, which has an assumed density, ρ, of 1.225 kgm^{-3} (air density at sea level) [4]. Air density decreases the further away from Earth it is. This means that there is a small error in this assumption, as the terminal velocity would therefore decrease slightly as the men got closer to the Earth. The cross-sectional area, A, of the two men is 0.7 m^2, when assumed they are directly on top of each other in a belly-to-earth position [5]. The drag coefficient, C_d, of a human is around 1 in this position [1].

$$v_t = \sqrt{\frac{2mg}{\rho A C_d}} = 58.58\, ms^{-1} \quad (1)$$

The terminal velocity of the two men is 58.85 ms^{-1}, which is faster than the typical terminal velocity of a skydiver at around 55 ms^{-1} [2]. This is due to the added weight but not added cross-sectional area, as they are falling whilst directly on top of each other.

To land from a parachute jump, it is recommended that you hit the ground at ~6 ms^{-1} to do so safely [6]. Therefore, the deceleration, a, to slow the terminal velocity to 6 ms^{-1} in 8 seconds must be found using equation 2 [2]. It is assumed that the parachute deploys and works instantly. The final velocity, v, is 6 ms^{-1}, the initial velocity, u, is 58.58 ms^{-1}, and the time, t, is 8 seconds.

$$v = u + at \tag{2}$$
$$a = \frac{v-u}{t} = -6.57 \text{ ms}^{-2}$$

This is used to find the force, F, exerted by the parachute to exhibit the deceleration using Newton's second Law of motion, equation 3. The mass is still 150 kg, as the weight of the parachute is assumed to be zero.

$$F = ma = 985.95\ N \tag{3}$$

Assuming that this force is equal to drag force, F_d, the cross-sectional area of the parachute is determined using equation 4. The drag coefficient is now that of a parachute, which is around 0.75 [7].

$$F_d = \frac{1}{2} C_d \rho A v^2 \tag{4}$$

$$A = \frac{2F_d}{C_d \rho v^2} = 59.62 \text{ m}^2$$

The canopy size of a parachute is measured in square feet, which makes this parachute 609.45 square feet. To put this into perspective, the average canopy size for an expert skydiver's parachute is 140 square feet [8]. Assuming Bodhi is an expert skydiver, this means the cross-sectional area of the parachute is 4.35 times the size of an expert's parachute.

The weight of the parachute is assumed zero for the sake of these calculations. In real life, normal sized parachutes can add around 10 kg of extra weight. As the parachute is so large, this would increase the terminal velocity and therefore the force required to slow them down to a safe speed. This is because both equation 1 and 3 are dependent on mass.

Conclusion

This paper uses terminal velocity, deceleration, and drag force to work out the feasibility of the famous scene from *Point Break*. It is found that Bodhi would have to have been wearing a parachute with a cross-sectional area of 59.62 m^2 to allow the two men to survive. This is 4 times larger than an expert skydiver's parachute, making it very large and heavy. With the parachute they had in the film they clearly would not have survived the fall.

References

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